Technology Development Program for an Advanced Microsheet Glass Concentrator

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OVERVIEW OF THE NASA LEWIS ADVANCED MICROSHEET GLASS CONCENTRATOR PROGRAM

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ABSTRACT

Solar Dynamic Space Power Systems are candidate electrical power generating systems for future NASA missions. One of the key components in a solar dynamic power system is the concentrator which collects the Sun's energy and focuses it into a receiver. In 1985, the NASA Lewis Research Center initiated the Advanced Solar Dynamic Concentrator Program with funding from NASA's Office of Aeronautics and Space Technology (OAST). The objectives of the Advanced Concentrator Program is to develop the technology that will lead to lightweight, highly reflective, accurate, scalable and long lived (7 to 10 years) space solar dynamic concentrators. The Advanced Concentrator program encompasses new and innovative concepts, fabrication techniques, materials selection, and simulated space environmental testing. This paper will discuss the Advanced Microsheet Glass Concentrator Program, a reflector concept, that is currently being investigated both in-house and under contract by the Perkin-Elmer Corporation of Danbury, CT.

INTRODUCTION

One of the key components in a solar dynamic power system is the concentrator. The concentrator is a parabolic mirror which collects the Sun's energy and focuses it into a receiver which heats the working fluid of a power conversion systems, i.e., a Brayton or Stirling engine. Concentrator development for space solar dynamic power was conducted by NASA in the late 1960's but was discontinued for lack of funding and a mission. Prior to 1984, when the Space Station began designing a solar dynamic power system, most of the solar dynamic concentrator work focused on terrestrial solar power. In 1985 the NASA Lewis Research Center initiated the Advanced Solar Dynamic Concentrator Program. The objectives of the Advanced Concentrator program are to develop the technology that will lead to lightweight, highly reflective, accurate, scalable and long lived (7 to 10 years) space solar dynamic concentrators. The long term goals of the program are to achieve a concentration ratio greater than 5000, a reflectance greater than 90 percent, surface accura-

cies of 0.5 to 1.5 mrad and a specific weight of 1 to 2 kg/m^2.

The Advanced Concentrator Program is divided into two parts. The first is Concentrator Concept Identification and Selection and the second is Supporting Research and Technology. The thrust of the Concept Identification Program is to develop innovative concentrator concepts and identify the critical technology issues associated with each. Whereas the Research and Technology Program directly addresses the critical technology issues. The foremost issues are concerned with the development of reflectors that meet or exceed the stated goals of the Advanced Concentrator Program (1).

Within the Research and Technology Program there are several in-house and contractor supported efforts which address the lightweight, highly specular and very smooth reflector issues. This paper will discuss the Advanced Microsheet Glass Program, a reflector concept, that is currently being investigated both under contract by the Perkin-Elmer Corporation of Danbury, CT and in-house at NASA Lewis. Microsheet glass is the name given to a family of soda lime glasses ranging in thickness from 1 to 20 mil; it has a definite width of 14 in., by virtue of its forming process, and an indefinite length. Microsheet glass is an excellent candidate for space solar concentrators because of its outstanding optical properties and it is impervious to atomic oxygen. It is also postulated the glass could minimize micrometeoroid damage. The objective of the Microsheet Glass Program is to determine the feasibility of bonding microsheet glass to a substrate material via adhesives without bubble entrapment and with minimum surface waviness. The major emphasis of the in-house program is placed on the substrate selection, cleaning and testing; adhesive screening, characterization and testing; and microsheet glass preparation. As part of the in-house program a cleaning procedure has been developed for the substrate and the microsheet glass, as well as a method for cutting and slumping the microsheet glass. Several adhesives that are being considered as bonding agents have been tested in the atomic oxygen asher and the results are quite encouraging. Preliminary thermal cycling tests have been performed, and the results tend to indicate that the rate and temperature at which the samples are cured has a

significant impact on the behavior of the induced thermal stresses. Therefore, a significant portion of the in-house effort is devoted to determining cure schedules and procedures for the various adhesives. The Advanced Microsheet Glass Program is approximately 2 years old and to date most of the effort has focused on the Perkin-Elmer concept and on establishing a lab to perform the in-house work. In the near future the program emphasis will be placed on analyzing the results of the atomic oxygen and thermal cycling tests performed on the Perkin-Elmer samples; and for the in-house program, developing a method for applying the adhesive to the substrate, applying the glass, and establishing a cure schedule.

MICROSHEET GLASS CONCENTRATOR PROGRAM

Perkin-Elmer
    In 1986 the Perkin-Elmer Corporation began a study for NASA Lewis to investigate the manufacturability of an extremely lightweight, self-supporting and highly reflective subscale concentrating panel suitable for use in space (2). This panel design, shown in Fig. 1, used microsheet glass to protect the panel from atomic oxygen and micrometeoroid damage while providing a smooth (specular) reflective surface.
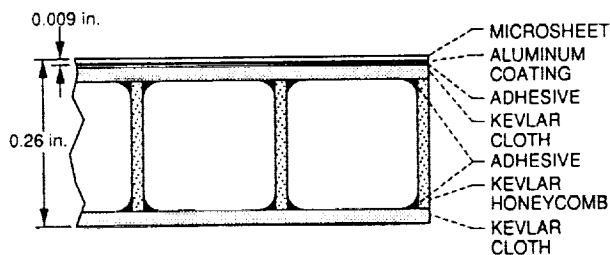

Figure 1. – Glass/Kevlar reflector panel configuration.

    Perkin-Elmer and their subcontractor Composite Optics Inc., found that handling of the microsheet glass (9 mil) was the most difficult aspect of the fabrication process. Prior to lamination to the facesheet, the glass is prone to severe cracking, thus special handling techniques were developed (2). Producing an accurate surface was the most challenging design issue. Dimpling, which results primarily from shrinkage in the honeycomb to facesheet fillet adhesive, due to a combination of cure shrinkage and post cure temperature changes, must be minimized to produce an accurate surface. It was therefore necessary to identify adhesives with curing temperatures close to the panel operating temperature. American Cyanamid's FM73 was selected as the adhesive for bonding the microsheet glass to the Kevlar facesheet, and Hysol 956 was the adhesive selected to bond the facesheets to the honeycomb core. After several iterations in the processes for coating, cleaning and bonding of the microsheet glass, Perkin-Elmer was able to produce both flat and curved panels which exhibited acceptable surface qualities.
    The more significant design considerations for the panel included surface accuracy, reflectivity, specularity, environmental durability, weight and manufacturability. The small scale manufacturability was demonstrated on several 0.13 m^2 coupons (2 in.^{2}), and spherical samples ranging from 0.15 to 0.35 m with a radius of curvature of 10 m. This concept also achieved the mass goal of the Advanced Concentrator Program, it had a specific mass of 1.65 kg/m^2. With the exception of environmental factors, described below, the results of the remaining design considerations are discussed in detail in Ref. 2.

    To determine the extent to which microsheet glass could protect Kevlar from atomic oxygen erosion and to what degree the adhesives were susceptible to atomic oxygen attack, a series of atomic oxygen asher tests were performed in-house on a 2-in.^{2} microsheet glass/Kevlar composite coupon. The coupon was cut into four sections; three sections were ashed for 432.5 hr (equivalent to 8.4 years in space) and the other was kept as a control (Fig. 2). The samples to be ashed were numbered 1, 2, and 4 they differed only in that sample 1 had all surfaces not covered by microsheet glass that were protected with aluminum foil tape; samples 2 and 4 had no protection and they differed in that sample 4 had a crack in the microsheet glass which ran its entire length. The criteria used to determine AO attack is mass loss, and the results of the asher tests indicated that sample 1 had a total mass loss of 4.92 percent, sample 2 had a mass loss of 14.23 percent and sample 4 had a mass loss of 15.72 percent (Fig. 3). The mechanism which led to mass loss in samples 2 and 4 can be directly attributed to the fact that the exposed Kevlar was not protected. The mass loss for sample 4 was slightly higher than that of sample 2, whether this is directly related to the crack in sample 4 remains to be determined. The area just below the crack on sample 4 was examined with an electron microscope to determine the effects of undercutting by the atomic oxygen. However, the results were inconclusive. Although all of the exposed Kevlar on sample 1 was protected, it still experienced a slight mass loss. At this time the mechanism(s) which led to this small, though not significant, mass loss has not been defined. It is believed that it could possibly be the result of a natural cleaning process where the AO actually cleans the surfaces or it could be the result of moisture evaporating from the sample. In all cases, the adhesive showed no apparent signs of attack. However, further AO tests were performed on the adhesives alone to determine whether they are indeed stable in an AO environment. The results of these tests are discussed in detail under the adhesives section of this paper.
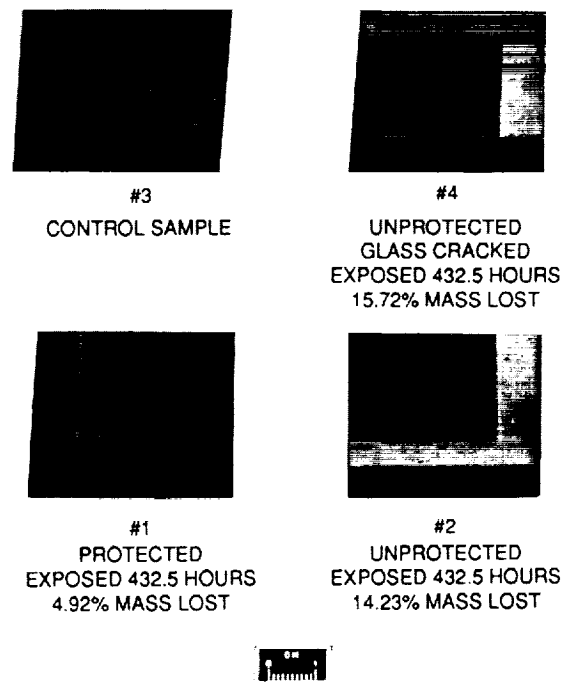

Figure 2. – Perkin–Elmer Kevlar/microsheet glass coupons after AO exposure.
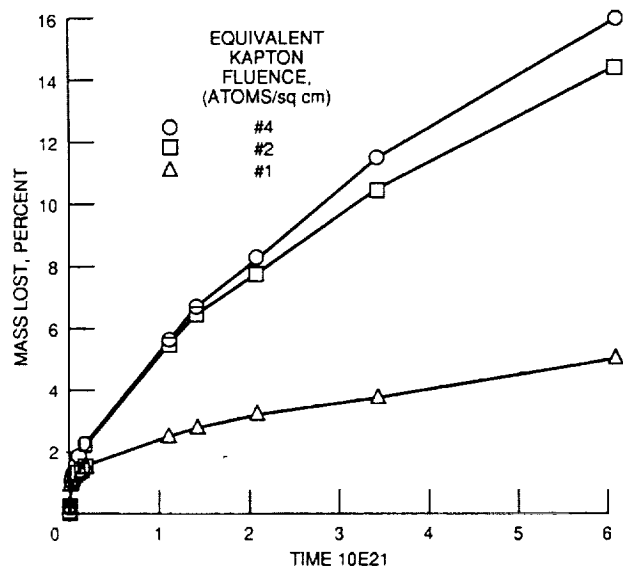
Figure 3. – Perkin–Elmer honeycomb samples.

The program described above served as the basis for a new Perkin-Elmer microsheet glass program which began in March 1988. Having investigated the manufacturability of the microsheet glass concept in the initial program, the major thrust of the follow-on program was to determine the panels resistance to degradation in low Earth orbit. The early stages of the follow-on program focused on thermal, structural and performance analysis. As a result of these analyses, the Kevlar/microsheet glass concept was replaced with a potentially more durable concept. The major differences in two concepts is that the Kevlar honeycomb core is replaced by an aluminum honeycomb core and the microsheet glass is aluminized on its front surface as opposed to its second/back surface (Fig. 4). The major advantages of this concept is that the aluminum is impervious to the atomic oxygen, and the panel operates at approximately 195 °C, thus reducing the occurrence of condensing contaminants.
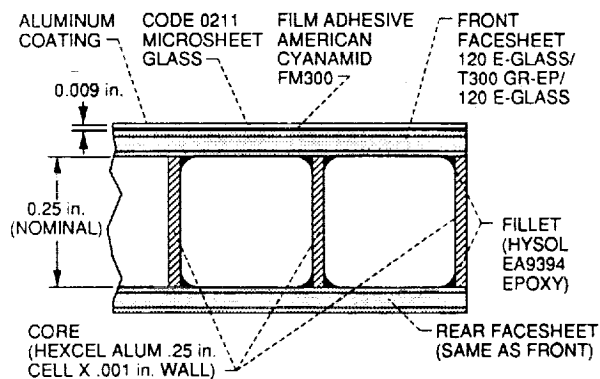

Figure 4. – Solar reflector coupon general specification – first surface reflector.

In addition to the thermal, structural and performance analysis performed early on for the aluminum/microsheet glass reflector panel (2), other considerations were coating and laminate designs, thermal cycling and AO testing. At this time all but the AO test results are pending or inconclusive. Just as the Kevlar/microsheet glass panel was tested in the AO asher at NASA Lewis so was the aluminum/microsheet glass sample. However, unlike the Kevlar sample the aluminum sample was not tested in sections. The entire

2-in. (2) sample was ashed for 372 hr (equivalent to 7.2 years in space). The total mass loss experienced by this sample was an acceptable 3.209 percent (Table I).

TABLE 1. – Al/μ-GLASS SAMPLE, ACCUMULATED DATA

[Initially exposed to vacuum for 25.5 hr.]

Time ashed, hr	Mass, m_o, g	Mass loss, $m_o - m_i$, g	Percent mass loss, $m_i - m_i/m_o$
0	8.34503	-------	-----
24.0	8.29922	0.04581	0.549
48.0	8.26682	.07821	.937
72.0	8.23528	.10975	1.315
147.0	8.17024	.17479	2.095
222.0	8.11801	.22702	2.720
297.0	8.09045	.25458	3.051
372.0	8.07723	.26780	3.209

NASA LEWIS IN-HOUSE PROGRAM

The Advanced Microsheet Glass Program at NASA Lewis began in June 1988. The objective of this program is to develop a technique for bonding microsheet glass to a metallic substrate via an epoxy resin. Initially a literature survey was performed in the areas of substrates, adhesives, and microsheet glass, e.g., glass forming, cutting, and cleaning. Aluminum was selected as the substrate material because of its extensive database, and it is a space qualified material. Throughout this program several adhesives have been identified and evaluated as candidates for bonding microsheet glass to a substrate. The following is a detailed discussion regarding the various technology issues associated with the substrate, the adhesive and the microsheet glass.

SUBSTRATE

A critical factor of advanced solar dynamic concentrators is the identification of candidate substrate materials. The material selected must be lightweight, space survivable and have structural integrity. Forming the substrate into a parabolic contour is an issue that must be addressed along with the ability to scale the substrate from a small test specimen to a full size concentrator. The materials that have been identified as candidates are; aluminum sheet, aluminum foam, aluminum honeycomb, beryllium, boron carbide foam, layered epoxy and Kevlar honeycomb.

Resistance to the environmental effects of space are critical in the selection of a substrate. As previously mentioned, the unprotected Kevlar reflector coupon experienced a 15.72 percent mass loss when tested for 432.5 hr in an AO asher. Protective coatings such as SiOx can be used to block out AO, or protect the substrate from the effects of undercutting. Another influence the environment has in the selection of a substrate is the effect of thermal cycling. The sun/shade cycles in space induce stresses that cause delamination and surface errors at interfaces where the CTE's are mismatched. The location of these stresses are at the substrate/adhesive, and at the adhesive/levelizing layer interfaces. The CTE of the substrate ideally should match that of the adhesive and coating (microsheet glass).

One potential concentrator petal configuration will consist of a 0.003 to 0.016 in. thick sheet of aluminum with 1 to 2 mil of epoxy bonded to a 3 mil glass facesheet. A typical element lay-up is configured in Fig. 5. The petal will float freely within a concentrator frame, and will rely upon the frame for structural rigidity. In this design the bulk of the
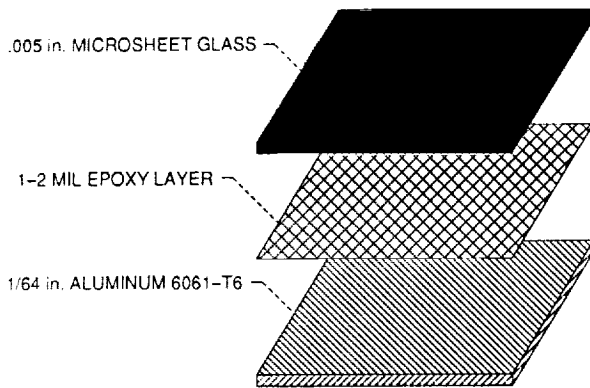
3

Figure 5. – Advanced microsheet concentrator lay-up.

.005 in. MICROSHEET GLASS

1-2 MIL EPOXY LAYER

1/64 in. ALUMINUM 6061-T6

overall weight will be the structure of the concentrator. This initial concentrator concept will reduce the effects of CTE mismatching, and the effects of thermal cycling because the petal is unrestricted. Another possible configuration is to bond the glass to an aluminum foam or aluminum honeycomb substrate. The substrate will provide the structural strength, and the overall weight will be dominated by the individual panels. The CTE of aluminum is approximately three times higher than that of microsheet glass, although it is close to that of several candidate adhesives. This differential in CTE's combined with the shrinkage of adhesives causes print-through on the front surface of the concentrator. Print-through refers to the pattern of the substrate being transposed to the surface of the levelizing layer (glass), causing surface errors that reduce the total specularity of the panel. The aluminum honeycomb and foam substrates, as compared to an aluminum sheet, have distinct patterns which can cause print-through and surface distortions to develop when bonded directly to the microsheet glass.

Parabolic contours can be formed using aluminum sheets via stretch forming, spin forming, or hydro-forming. The aluminum honeycomb will take on the parabolic contour when it is bonded to the formed aluminum sheet in a vacuum bag. A milling machine will be used to contour the aluminum foam. The aluminum plates and honeycomb do not show any potential problems in scaling the test samples to a full size concentrator. Aluminum foam technology is in the early stages of development and its size is limited to the manufacturing process. Other potential lightweight substrates will be considered in the future after a database has been established using aluminum as a baseline material.

MICROSHEET GLASS

Microsheet glass is a very thin (1 to 20 mil) sodalime glass that will provide a leveling layer for solar concentrators. Glass is by far one of the most optical materials available for concentrators, and has been used on many terrestrial concentrators where weight is less significant. Glass is impervious to the effects of AO, and ultraviolet radiation. Glass has a high modulus to weight ratio under compression, this will add to the structural rigidity of the total concentrator. Due to the high density of glass, an all glass panel will be too massive for space application compared to a 3 mil microsheet glass panel bonded to a metallic substrate. In-house evaluation indicated that Microsheet glass coated with aluminum is over 90 percent reflective with less than a 1 mrad slope error. The width of the microsheet glass is limited to 15.5 in. due to manufacturing restrictions and has an indefinite length thus limiting the size of the concentrator.

ADHESIVES

A critical part of the Advanced Microsheet Glass Concentrator program has been the identification of candidate adhesives. Similar to the substrate, the adhesive must be survivable in the space environment, i.e., impervious to AO and UV radiation, and maintain vacuum stability (minimal outgasing). It is desirable for the shrinkage of the adhesive, upon curing, to be less than one percent, and have a minimal affinity for water absorption. The CTE of the adhesive should be a close to that of aluminum and microsheet glass as possible (5 to 13×10^{-6} in./in./°F). It is important for the viscosity of the adhesive to be low enough for flo' and levelizing during application. Emmerson and Cummings EP-3, and Dow Cornings DC-93-500 are two leading candidate adhesives being investigated. Emmerson and Cumming has not qualified EP-3 for space application, although it has been proven to be an excellent levelizing material. Both will be researched in parallel along with other potential adhesives.

EP-3 is a two part epoxy that was designed to be an industrial coating with a low viscosity. The EP-3 epoxy will be applied with a spray gun to the aluminum substrate mounted in the vertical position. The spraying will take place in a mini cleanroom which was designed and fabricated at NASA Lewis. The mini cleanroom is a 2.5 by 2.5 by 5.0 ft glove box that is designed to filter particles 0.3 μm in diameter which is 300 times smaller than the diameter of a human hair (Fig. 6). The coating thickness can be controlled to within 1 mil. Methyl Ethyl Ketone, Toluene, and Methyl Isobutyl Ketone can be used as thinners to control the levelizing and flow characteristics of the EP-3 epoxy. After the epoxy has been applied it is critical to allow the panel to outgas for 30 min, or the trapped gases will create a void between the glass and the aluminum. After allowing the epoxy to outgas, the glass is applied to the substrate and placed in a vacuum bag and cured for 6 hr at 100 °C. The EP-3 has a lower viscosity than that of DC-93-500 therefore it is easier to control the coating thickness. Upon curing, the EP-3 epoxy hardens and will not allow the aluminum substrate and the microsheet glass to move relative to one another, due to a CTE mismatch, when thermally cycled. Whereas, DC-93-500 has the consistency of rubber, and will allow the glass and aluminum to act as separate plates.
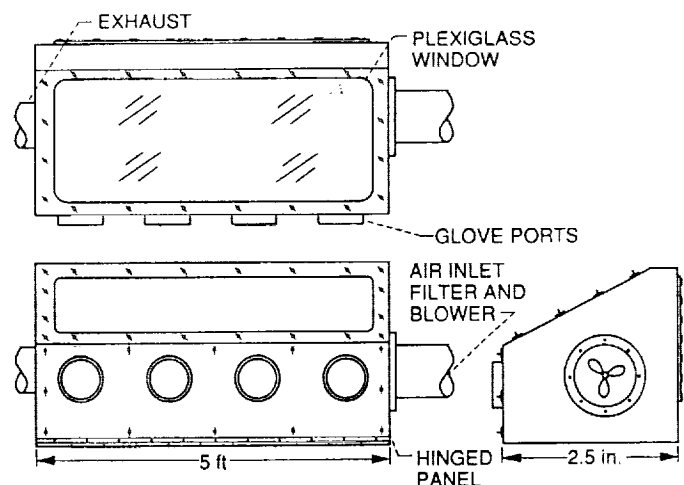

Figure 6. – Dry box/clean chamber for advanced concentrator development.

DC-93-500 is the adhesive used to bond microsheet glass to Space Station Freedom's (SSF) photovoltaic solar cells. NASA Lewis has thermally cycled the microsheet glass bonded to a Silicone cell with DC-93-500 60 000 times over a temperature range from -100 to 100 °C without any cracks. The DC-93-500 is applied with a spatula onto a grid template which is placed on the backside of the microsheet glass with the face of the glass on a mandrel. The template is then removed leaving small rectangles of DC-93-500 on the backside of the glass. The distance between the rectangles are precalculated so that when the aluminum substrate is applied, the adhesive fills all voids without flowing out of the edges. The panel is then vacuum bagged and uniformly pressurized with approximately 1 lb/in.^{2}.

The adhesives used by Perkin-Elmer were applied to separate stainless steel plates and tested in an atomic oxygen environment (asher). Perkin-Elmer supplied two low temperature adhesives (Hysol EA956 and American Cyanamid FM73) used in the initial/Kevlar panel design, and two high temperature adhesives (Hysol EA9394 and American Cyanamid FM300) used in the follow-on/aluminum panel design. The American Cyanamid adhesives are used for bonding the microsheet glass to the facesheet, and the Hysol adhesives were used to bond the facesheets to the honeycomb core. The results of the asher tests, shown graphically in Fig. 7, indicated that the Hysol EA9394 (number 5) was the most durable adhesive experiencing a mass loss of only 5.39 percent after 143.5 hr of exposure. The second most durable adhesive was the American Cyanamid FM300 (number 7), it experienced a total mass loss of 8 percent after 114.5 hr. These results are in line with Perkin-Elmer's expectations.
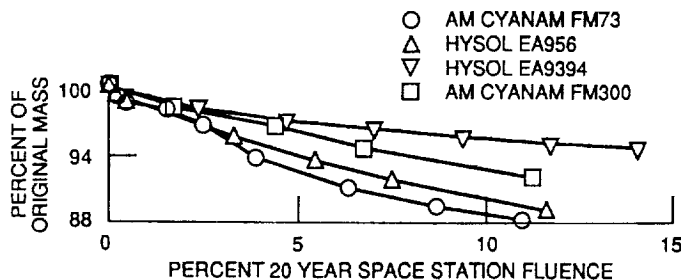

Figure 7. – Perkin-Elmer adhesive samples percent mass loss versus ashing time.

The low temperature adhesives proved to be less durable. The Hysol EA956 (number 1) experienced a 10.9 percent mass loss after only 118.5 hr of AO exposure. The asher tests were stopped at this point because the effects of the AO exposure had become established. The EA956 exhibits a steady, essentially linear loss in mass. The American Cyanamid FM73 (number 3) experienced the greatest mass loss of 11.74 percent after 112 hr of exposure. As previously mentioned, during the Kevlar panel AO tests these adhesives showed no visible signs of attack; however, it can be deduced that the undetectable mass loss of the adhesives was at least one of the mechanisms leading to the significant mass loss of the samples with unprotected surfaces.

PREPARATION

As part of the in-house program a cleaning procedure has been proposed for the substrate and the microsheet glass, as well as a method for cutting and slumping the microsheet glass. The procedures listed below are intended to be used as an aid in concentrator development.

Cleaning Procedure

Substrate. - In-house tests have indicated that the cleaning procedure used on the substrate has a direct effect on the quality of the levelizing layer. Improper cleaning reduces the bond strength causing the microsheet glass to delaminate from the aluminum substrate. The cleaning procedure adapted for the aluminum foil is described below (3).
(1) Remove grease, oil, etc. by vapor degreasing or solvent cleaning.
(2) Immerse 8 to 12 min in an Alkaline solution of Oakite 61B cleaner.
(3) Rinse thoroughly with deionized water.
(4) Immerse 10 to 12 min at 150 to 160 °F in the following solution

Demineralized water . . . . . . 30 parts
Sulfuric acid . . . . 10 parts
Sodium dichromate . . . . 1 part

(5) Rinse thoroughly in deionized water so the final pH will be between 8.5 and 5.0.
(6) Air or oven-dry sample at temperatures up to 150 °F.
(7) Perform a water break test. If the water breaks, repeat steps 1 to 5. Store in clean environment up to 4 to 6 hr.

Microsheet Glass. - The proposed cleaning procedure for microsheet glass was developed at NASA Lewis as part of the Microsheet Glass In-House Program.
(1) Remove grease, oil, etc. by vapor degreasing or solvent cleaning.
(2) Immerse 8 to 12 min in an ultrasonic cleaner with a solution of Micro lab cleaner.
(3) Rinse thoroughly in deionized water so the final pH will be between 8.5 and 5.0.
(4) Air or oven-dry sample at temperatures up to 150 °F.
(5) Perform a water break test. If the water breaks, repeat steps 1 to 5. If the glass is determined to be clean, store it in a clean environment for 4 to 6 hr.
(6) Apply a thin coat of Chemlock AP 134 to prep the glass for bonding with a nonshedding swab. Bond the glass to the substrate within 1 hr after application of the AP 134.
Step 6 is to be administered after heat forming the microsheet glass to the parabolic contour.

Cutting Procedure for Microsheet Glass

NASA Lewis has defined a procedure for cutting the glass. A diamond tipped scribe dipped into a SAE 30 oil is used to score the glass. A template, suspended about 1 to 3 mil above the glass, is used to achieve the desired shape and to steady the glass. After a clean score is generated on the glass, even pressure is applied on either side of score line to make the final cut. After the glass has been cut it is necessary to polish the edges to reduce the effects of microcracks. This is achieved by stacking the glass sheets together and applying a water slurry with a brush wheel to the edges. The residue from the SAE 30 oil and water slurry must be removed from the glass prior to the forming process.

Forming Procedure for Microsheet Glass

NASA Lewis has proposed a procedure for slumping microsheet glass into a parabolic contour. A graphite

mold is machined to the contour of a parabola of one of the concentrator segments. A sheet of 0.25 in. Pyrex glass is then placed on top of the graphite mold and slumped to the parabolic contour. The Pyrex sheet will then be used as a glass master to slump the microsheet glass. It should be noted that the top surface of the Pyrex glass will be the final contour of the parabola and that the graphite mold will be machined to compensate for the 0.25 in. thickness of the Pyrex (Fig. 8). This approached evolved from an initial approach where the microsheet glass was formed directly on the graphite mold. It was found that the surface imperfections which existed in the graphite surface were transferred to the microsheet glass.
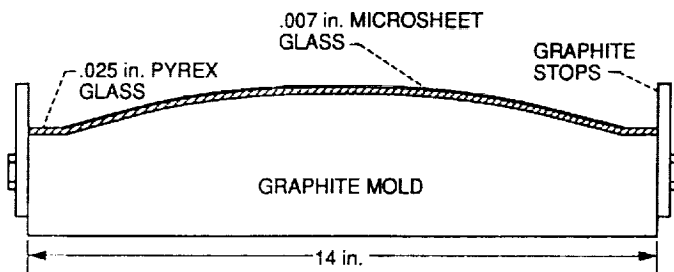

Figure 8. – Glass forming mold.

The critical temperatures for forming microsheet glass are listed in Table II. Initially, the microsheet glass is heated to a temperature just below that of the softening point, and held for 30 min. The glass is cooled to a point just above the annealing point and held for 1 hr. The glass is then cooled slowly (3 to 5°/min) to a temperature just below the strain point.

TABLE 2. - CRITICAL TEMPERATURES FOR MICRO-SHEET GLASS

	Viscosity, P	Temperature, °C	Temperature, °F
Working point	10^4	1008	1847
Softening point	10^6	720	1328
Annealing point	10^{13}	550	1022
Strain point	10^{15}	508	941

The power is turned off and the glass is cooled to room temperature. A vacuum furnace with an Argon backfill is used for this procedure. After the glass has cooled, the cleaning procedure previously discussed is used. After cleaning, the glass prep agent Chemlock AP 134 is applied to prepare the glass for bonding.

CONCLUDING REMARKS

The Advanced Microsheet Glass Program holds much promise for achieving the objectives of the Advanced Solar Dynamic Concentrator Program, i.e., technology development for space concentrators that are lightweight, highly reflective, highly accurate, scaleable and long lived (7 to 10 years).

The current Perkin-Elmer effort is scheduled to be completed by the end of 1989 and at this time only the results of the thermal cycling tests are incomplete.

The in-house program has identified procedures for bonding microsheet glass to a substrate with minimal surface error, and cleaning both the microsheet glass and the aluminum substrate. Emmerson and Cummings EP-3 and Dow Cornings DC 93-500 have been selected as bonding agents to secure the microsheet glass to the aluminum plate. The procedures identified thus far in the in-house program are for bonding microsheet glass to a flat aluminum substrate. Upon successfully demonstrating the feasibility of this technique, the NASA Lewis Advanced Concentrator personnel will apply the technology to parabolic contoured elements and address the issue of scaling to larger power levels.

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16. Abstract

Solar Dynamic Space Power Systems are candidate electrical power generating systems for future NASA missions. One of the key components in a solar dynamic power system is the concentrator which collects the sun's energy and focuses it into a receiver. In 1985, the NASA Lewis Research Center initiated the Advanced Solar Dynamic Concentrator Program with funding from NASA's Office of Aeronautics and Space Technology (OAST). The objectives of the Advanced Concentrator Program is to develop the technology that will lead to lightweight, highly reflective, accurate, scaleable and long lived (7 to 10 years) space solar dynamic concentrators. The Advanced Concentrator program encompasses new and innovative concepts, fabrication techniques, materials selection, and simulated space environmental testing. This paper will discuss the Advanced Microsheet Glass Concentrator Program, a reflector concept, that is currently being investigated both in-house and under contract by the Perkin-Elmer Corporation of Danbury, CT.

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